



## Diagnosing kinesthetic intelligence through innovative e-assessment of motion literacy based on laban dance notation

*Diagnóstico de la inteligencia cinestésica mediante e-evaluación innovadora de la alfabetización en movimiento basada en danza laban*

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### Abstract

**Introduction and Objective.** Assessment in dance education must integrate cognitive understanding and motor execution to accurately diagnose kinesthetic intelligence. This study aims to develop an innovative e-assessment model for motion literacy based on Laban dance notation to objectively diagnose kinesthetic intelligence among junior high school students.

**Methodology.** This research employed a Research and Development (R&D) approach. The model was designed based on a Focus Group Discussion with junior high school arts teachers and validated through the Delphi method involving experts in dance education, information technology, and educational measurement. Field trials were conducted with 79 students from five administrative regions of Jakarta. Data were analyzed descriptively and inferentially to examine motion literacy knowledge, movement skills, and user acceptance.

**Results.** Knowledge scores ranged from 20 to 100 with a mean of 70, indicating moderate understanding of Laban notation. Movement skill performance varied across participants and was influenced by device limitations. Automated scoring successfully provided immediate feedback. User acceptance analysis revealed high levels of usability and learning engagement, with two dominant factors: usability and learning value.

**Conclusions.** The Laban notation-based e-assessment model is effective and reliable for diagnosing kinesthetic intelligence in school contexts. Despite technological constraints, the model offers an innovative, meaningful, and objective approach to motion literacy assessment in dance education.

### Keywords

Kinesthetic intelligence; laban notation; motion literacy; e-assessment; dance education.

### Resumen

**Introducción y Objetivo.** La evaluación en la educación de la danza debe integrar el conocimiento cognitivo y la ejecución motriz para diagnosticar con precisión la inteligencia cinestésica. El objetivo de este estudio fue desarrollar un modelo innovador de e-evaluación de la alfabetización del movimiento basado en la notación de danza Laban.

**Metodología.** La investigación utilizó un enfoque de Investigación y Desarrollo (I+D). El modelo se diseñó a partir de un grupo focal con docentes de Artes y Cultura y se validó mediante el método Delphi con expertos en danza, tecnología de la información y evaluación educativa. La prueba de campo involucró a 79 estudiantes de secundaria en cinco regiones de Yakarta. Los datos se analizaron de forma descriptiva y correlacional.

**Resultados.** Las puntuaciones de conocimiento oscilaron entre 20 y 100, con una media de 70. El desempeño motriz presentó variaciones, influenciadas en parte por limitaciones tecnológicas. El sistema de puntuación automática proporcionó retroalimentación inmediata. La aceptación del usuario fue alta, destacándose la usabilidad y el valor educativo.

**Conclusiones.** El modelo de e-evaluación basado en la notación Laban es válido y eficaz para diagnosticar la inteligencia cinestésica. Este enfoque ofrece una solución innovadora y significativa para la evaluación del aprendizaje del movimiento en la educación artística.

### Palabras clave

Inteligencia cinestésica; notación laban; alfabetización de movimiento; e-evaluación; educación de danza.

## Introduction

Assessment frameworks in 21st-century education are designed to align with broader skill and knowledge demands in an increasingly digital and globalized context (Hardiansyah et al, 2024). Evaluation has become more holistic, focusing on developing students' capacity for lifelong learning. Technology enables data-driven assessment that is both more effective and efficient (Pusvisasari et al, 2024), as exemplified by platforms such as Edmodo, Quizizz, Google Forms, and Kahoot. When technology is integrated into assessment, it provides rapid feedback and supports personalized learning processes. Furthermore, technology facilitates the evaluation of critical thinking, digital literacy, and technological proficiency (Triana et al, 2020). Assessment in 21st-century education has shifted toward more holistic and technology-supported approaches that emphasize not only knowledge acquisition but also skill development and lifelong learning capacities (Hardiansyah et al, 2024). The integration of digital technology in assessment practices enables more efficient data collection, rapid feedback, and personalised learning experiences, particularly in school contexts where student engagement and learning effectiveness are critical.

Technological literacy in assessment can be achieved through the implementation of e-assessment, or digital-based evaluation. Digital assessment is increasingly employed in school programmer (Fuentes et al., 2022). Recent studies in Retos also highlight the effectiveness of gamification and technology in enhancing student engagement and physical fitness education (Çakır et al, 2025; Lolowang et al., 2025). Recent studies published in Retos highlight the increasing role of technology and gamification in physical and movement-based education. Çakır et al. (2025) reported that gamified learning environments significantly enhance student engagement and participation in physical education, while Lolowang et al. (2025) demonstrated that technology-supported instructional strategies improve motivation and learning outcomes in fitness and movement learning. Despite these advances, most studies focus on general engagement and performance outcomes, with limited attention to structured motion literacy assessment and automated scoring systems for diagnosing kinesthetic intelligence. In learning and assessment activities, students are expected to solve problems through communication, collaboration, information literacy, and media and technological competence, encompassing information, media, and digital literacy (Lai & Viering, 2012). Consequently, assessment quality becomes paramount, necessitating electronic media that offer superior accuracy and precision.

The evolution of assessment practices through technological integration has been substantially accelerated by COVID-19, resulting in rapid systemic transformation (Del Valle Díaz et al, 2022). Skill tests traditionally conducted through direct observation have now transitioned to digital portfolios (González et al, 2025). Changes in assessment strategies to measure competence in complex global environments reflect evolving demands of professional success. (Wiggins & McTighe, 2007) Innovative assessment and learning strategies that teach collaborative work will reflect capacity for future success. (Bell, 2010) Technology-based assessment is also employed to measure abilities that demand motor skills.

Dance education presents a distinctive case, measuring not merely movement execution but also cognitive and affective capabilities. When learning to dance, students must perceive movement, cognitively process what is perceived, and express it through physical action. Dance education represents a unique learning domain in which cognitive, psychomotor, and affective dimensions are inseparably intertwined. Students are required not only to execute movements but also to understand, interpret, and consciously express movement structures. This process involves motion literacy, defined as the ability to read, interpret, and communicate meaning through movement symbols, particularly through systems such as Laban dance notation (Bucek, 1998; Dils, 2007). Motor learning in dance involves several stages, including cognitive, associative, and autonomous phases, which describe how learners progress from understanding movement concepts to executing movements fluently and accurately (Taylor & Ivry, 2012; Tenison et al., 2016). These stages are particularly relevant in junior high school (SMP) students, who are undergoing rapid physical and cognitive development and are increasingly familiar with digital technology (Lutz et al., 1988). Expressing movement is fundamentally cognitive, as motion activates neural networks throughout the body, thereby optimizing learning by engaging sensorimotor functions that influence literacy skills, including reading, writing, and oral recounting (Luppe, 2007). Motor learning encompasses three distinct stages: cognitive, associative, and autonomous (Taylor & Ivry, 2012).



In dance learning, cognitive stage is necessary for developing comprehensive movement understanding, from processing to movement execution. The associative stage consciously controls motion and links it to outcomes, while the autonomous stage represents the highest level of movement mastery, producing accurate execution (Tenison et al, 2016). Consistent with these stages, movement in dance relates to kinesthetic intelligence, which has been shown to contribute to improved memory and practical knowledge application. When students engage in direct activities, they develop stronger connections between conceptual understanding and physical experience, creating more robust and durable memory traces (Oladele, 2024).

Kinesthetic techniques in dance learning can stimulate cognitive development, particularly through structured exercises incorporating Laban dance notation. Students must read Laban movement symbols, grasp their significance, and translate them into action, a process termed motion literacy in dance (Bucek, 1998). Research has demonstrated that adapting Laban notation symbols facilitates student development of both motor and kinesthetic skills (Triana et al, 2019; Triana & Yudha, 2021) (Triana et al, 2020) (Dania et al, 2015)

The conveyance of kinesthetic meaning through movement symbols is known as Laban notation. Created in the nineteenth century by Rudolf Laban, this system was designed to understand, describe, and document human movement in dance (Guest, 2013). Consequently, students must develop competence in reading movement symbols, interpreting their meaning, and expressing this interpretation through motion. This process constitutes literacy, understood not merely as the ability to read text but as the capacity to interpret and convey meaning through multiple sign and symbol systems encompassing kinesthetic, visual, and aural modes of communication (Dils, 2007).

Reading Laban notation for motion literacy requires significant cognitive effort (Warburton, 2000). Consequently, game-based learning is essential to prevent students from feeling overwhelmed, as games create engaging conditions for applying Laban notation and render dance learning enjoyable (Triana et al, 2024). Games require scoring systems to indicate proficiency or skill level, which impacts motivation. Scoring mechanisms are implemented through game dynamics, whereby scoring stimulates player motivation and engagement (Jasni et al, 2018). Game systems employing scoring are comparable to assessment, as game skills are measured and evaluated through accurate scoring systems (Lee et al., 2016).

Previous research has addressed motion literacy through game-based approaches (Triana et al, 2024), yet implementation has proven impractical, requiring expensive equipment such as the Kinect Box 360, in addition to needing monitors and motion sensors with limited effectiveness. Furthermore, these earlier systems lacked integrated scoring for reading and meaning-making processes; students received insufficient feedback and motivation due to the absence of scoring mechanisms for symbol comprehension before movement execution (Triana et al, 2024).

This research addresses these limitations by developing an e-assessment model for motion literacy based on Laban notation. A digital-based objective scoring system is intended to enhance movement learning quality for Junior High School students, providing awareness, meaningfulness, and enjoyment consistent with deep learning principles (Biggs & Moore, 1993) whilst enabling students to acquire knowledge through responding to global change, processing novel information, engaging with new technologies, and creating meaning in a complex world (Arstorp, 1992).

Following years of development from 2019 to the present, technology-enabled e-assessment represents a practical solution, requiring a perfected scoring system to accurately measure motion literacy skills using Laban symbols and thereby diagnose kinesthetic intelligence. Laban Movement Analysis (LMA) demands kinesthetic intelligence, as intelligence cannot operate independently but maintains an intimate connection with human cognitive function (Hariono et al., 2024). Integrating kinesthetic intelligence measurement with motion literacy in deep learning contexts through e-assessment equipped with objective scoring systems enables the determination of students' kinesthetic intelligence levels.

Based on prior research, the research problems are formulated as follows: (1) How can an e-assessment model for motion literacy based on Laban dance notation be developed to diagnose kinesthetic intelligence in SMP students? (2) How can an accurate automated scoring system be designed for motion literacy assessment based on Laban dance notation that diagnoses SMP students' kinesthetic intelligence? (3) How can digital technology be integrated into motion literacy assessment to enhance accuracy and efficiency in diagnosing kinesthetic intelligence?



Students at the SMP (Middle School) level experience transition from childhood to adolescence, characterized by rapid physical development, evolving cognitive patterns, and negotiation of social and emotional identity. At this stage, SMP students begin mastering new concepts and demonstrate proficiency with technology (Lutz et al, 1988). To align instructional approaches with these unique physical and technological characteristics, integrating movement into digital interaction becomes essential. Research on game design and interaction using movement in digital games has become increasingly prevalent (Mueller & Isbister, 2014), as employing body movement makes computer-based games more accessible and promises more natural and engaging player experiences (Bianchi-Berthouze, 2013). In this study, several terms are used consistently: Research and Development (R&D) refers to the systematic process of designing and validating educational products; Focus Group Discussion (FGD) denotes structured discussions with subject teachers; Delphi method is an expert-based validation technique conducted through iterative rounds; and SMP refers to Indonesian junior high school level students.

Building on this potential, further investigation focusing on movement and diagnosing kinesthetic intelligence through digital scoring systems is necessary. This research addresses gaps in motion literacy assessment methods by developing a Laban notation-based e-assessment model. Through objective digital-based scoring, this work aims to improve movement learning quality for SMP students, providing an innovative solution for accurate and efficient movement skill assessment.

Problem-solving approach integrates kinesthetic intelligence through Laban Dance Notation in E-Assessment to diagnose kinesthetic intelligence through methods combining data-driven approaches and accurate, practical, user-friendly kinesthetic intelligence measurement, making dance learning meaningful and enjoyable.

The primary contribution of this research lies in integrating Laban dance notation, e-assessment, and an automated scoring system into a single technology-based assessment model to diagnose kinesthetic intelligence in SMP students. This approach remains largely unexplored in educational contexts and represents an innovative solution for accurate and efficient movement skill assessment.

Although previous research has explored motion literacy and technology-based dance learning, several limitations remain. Many existing approaches rely on expensive motion-sensing devices, require complex infrastructure, or lack integrated automated scoring systems. Moreover, prior studies often focus primarily on movement performance outcomes without explicitly assessing students' ability to read, interpret, and meaningfully translate Laban dance notation into movement, which is essential for diagnosing kinesthetic intelligence.

To address these gaps, this study develops an innovative Laban dance notation-based e-assessment model equipped with an objective automated scoring system. The model integrates cognitive aspects of motion literacy knowledge with psychomotor movement skills to diagnose kinesthetic intelligence among SMP students. Informed by Focus Group Discussions with MGMP Arts and Culture teachers and validated through the Delphi method, the e-assessment model is designed to accommodate technological limitations commonly found in school contexts. Furthermore, the model aligns with deep learning principles by promoting meaningful, conscious, and enjoyable learning experiences in dance education.

## Method

This research employed a Research and Development (R&D) approach to systematically design, develop, and validate an e-assessment model for motion literacy. The development process integrated multiple stakeholder perspectives through focus group consultation, followed by iterative expert validation and field testing with authentic student populations.

### *Research Design*

This research employed a Research and Development (R&D) approach to design, develop, and validate the e-assessment model. The initial phase involved a Focus Group Discussion (FGD) with Arts and Culture teachers from Junior High Schools across DKI Jakarta. Two representatives from each of the five administrative regions (West, East, South, Central, and North Jakarta) participated to ensure diverse perspectives regarding curriculum requirements and student characteristics. This study employed a Research and Development (R&D) approach to design, develop, and validate an e-assessment model for



motion literacy based on Laban dance notation. The R&D process was conducted through sequential stages, including needs analysis, model design, expert validation, revision, and field trials. This approach was selected to ensure that the developed model was theoretically grounded, empirically tested, and practically applicable in junior high school dance education contexts.

### ***Development Procedure and Validation***

The development process began with a Focus Group Discussion (FGD) involving Arts and Culture teachers from the MGMP (Musyawarah Guru Mata Pelajaran) at the junior high school level in DKI Jakarta. Two teacher representatives from each administrative region participated in the discussion to align the model with curriculum demands, student characteristics, and technological conditions.

Based on the FGD results, a prototype motion literacy e-assessment game was developed. The prototype was subsequently validated using the Delphi method involving three experts: a dance education specialist, an information technology expert, and an assessment and measurement expert. The validation focused on conceptual alignment, content suitability, interface design, and scoring accuracy. Revisions were conducted iteratively until expert consensus was achieved.

Following FGD outcomes, a prototype motion literacy game was developed. This prototype underwent rigorous expert validation through the Delphi method involving three expert panels: an Arts and Culture teacher (content specialist), an IT professional (technical specialist), and an instrument measurement expert (evaluation specialist). The Delphi method facilitated iterative design refinements until consensus was achieved. Key modifications included regulating movement tempo (practices 5 and 6 were initially too rapid), redesigning the interface for improved symbol legibility on small screens, and optimizing software for Windows laptops to accommodate students with limited mobile phone specifications.

To evaluate the e-assessment model in authentic educational contexts, field trials were conducted with student participants across multiple schools.

#### ***Instrument and Measurements***

Data were collected using three primary instruments. First, motion literacy knowledge was measured through a digital knowledge test assessing students' ability to recognise, read, and interpret Laban dance notation symbols. Second, movement skills were assessed through six progressive practice tasks embedded within the e-assessment application. Each practice required students to execute movements according to specific spatial, temporal, and effort components derived from Laban notation.

Third, student acceptance of the e-assessment model was measured using a twelve-item questionnaire covering two dimensions: Usability and Interface Satisfaction (4 items) and Learning Value and Engagement (8 items). All questionnaire items were rated on a five-point Likert scale.

#### ***Automated Scoring System***

The e-assessment application incorporated an automated scoring system that recorded timing accuracy and movement execution errors at each count. Students received immediate feedback after completing each practice, including total scores and indications of movement segments requiring improvement.

Considering variations in students' device specifications, the application was optimised for both mobile devices and Windows-based computers or laptops. This adjustment was implemented to minimise technical barriers, particularly for students whose mobile devices did not meet the required memory specifications.

### ***Participants and Sampling***

The participants consisted of 79 junior high school (SMP) students drawn from a population of 100 students across five administrative regions of DKI Jakarta, namely Central, West, East, South, and North Jakarta. Schools were selected using purposive sampling to represent diverse socioeconomic backgrounds, technological access levels, and learning environments.

Each participating school contributed approximately ten students who met the inclusion criteria: (1) being actively enrolled in arts or dance learning, (2) having basic experience using digital devices, and (3) providing consent to participate in the e-assessment trial. This sampling strategy ensured that the model was tested across varied school contexts while remaining feasible for field implementation.



Field trial participants included 79 students selected from a larger population of 100 students across schools located in the five regions of DKI Jakarta. The participating institutions included SMP Negeri 159 Jakarta, SMP Negeri 215 Jakarta, SMP Negeri 39 Jakarta, SMP Negeri 216 Jakarta, SMP Negeri 254 Jakarta, SMP Negeri 238 Jakarta, SMP Negeri 62 Jakarta, SMP Negeri 283 Jakarta, and SMP Mekar Tanjung Jakarta.

Baseline Digital Competencies: to contextualize students' technological preparedness for e-assessment. engagement, their self-reported proficiency in common digital activities was assessed. Table 2 presents competency levels across six routine ICT tasks in 2020 and 2021.

Table 2. Self-Reported Proficiency in Common Digital Activities (2020–2021)

Activity	Level of Competition	2020	2021
Do a job in Word by formatting it well	I never did	3%	-
	You could do it with help	22%	9%
	I can do it alone	75%	91%
Make an Excel spreadsheet by uploading a list of classmates and the telephone numbers of each one	I never did	9%	9%
	You could do it with help	44%	34%
	I can do it alone	47%	57%
Send an email with a document or image attached	I never did	9%	-
	You could do it with help	9%	6%
	I can do it alone	82%	94%
Edit the size or color of an image using Paint or an app on your phone	I never did	-	-
	You could do it with help	31%	12%
	I can do it alone	69%	88%
Share a document with another person using collaborative tools (e.g. Google Drive)	I never did	19%	3%
	You could do it with help	22%	9%
	I can do it alone	59%	88%
Create videos	I never did	28%	-
	You could do it with help	34%	31%
	I can do it alone	38%	69%

Results showed substantial improvement in independent performance between 2020 and 2021, particularly in email communication (82% to 94%), image editing (69% to 88%), and collaborative document sharing (59% → 88%). However, more complex tasks, such as video creation and spreadsheet management, continued to show significant proportions of students requiring assistance, highlighting.

### *Potential barriers to technology-intensive assessment tasks*

The participating institutions represent diverse socioeconomic contexts across Jakarta's administrative regions, ensuring a representative sampling of student populations with varying technological access and baseline kinesthetic experiences. School selection followed strategic sampling criteria to include both metropolitan and peripheral locations, thereby capturing variations in digital infrastructure and student preparedness.

### **Data Collection and Analysis**

Data analysis employed a mixed-methods approach. Descriptive statistics were used to summarise students' motion literacy knowledge and movement skill scores. Pearson correlation and linear regression analyses were conducted to examine the relationship between knowledge (V2) and skill performance (V3).

To evaluate student acceptance of the e-assessment model, reliability analysis using Cronbach's Alpha was performed, followed by Exploratory Factor Analysis (EFA) to identify underlying dimensions of usability and learning engagement. All statistical analyses were conducted using appropriate significance thresholds ( $p < 0.05$ ).

Data were collected using multiple instruments and analytical techniques to comprehensively evaluate the e-assessment model across cognitive, psychomotor, and affective dimensions. A mixed-method analytical strategy was employed:

- Descriptive Statistics: Distribution of Knowledge (V2) and Skill (V3) scores were profiled.

- Correlation and Regression Analysis: Pearson correlation and Linear Regression examined relationships between theoretical knowledge and practical skill execution.
- Exploratory Factor Analysis (EFA): A twelve-item usability survey was subjected to EFA to identify latent dimensions of student acceptance (Usability versus Engagement).

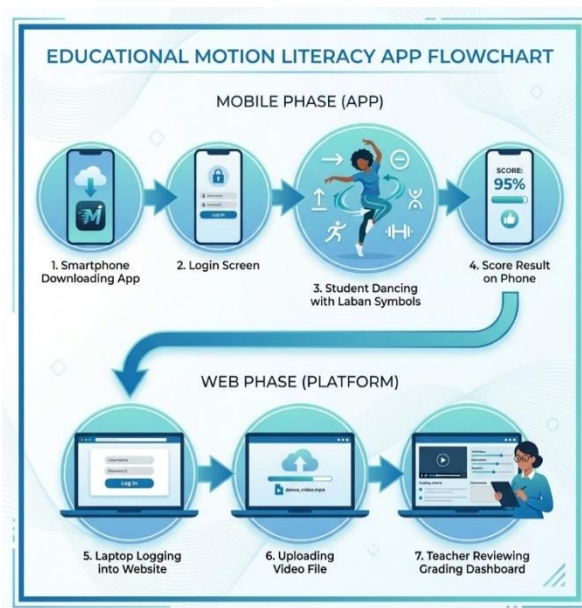
Reliability Assessment: Cronbach's Alpha was calculated to verify internal consistency of the acceptance questionnaire.

## Results

### *E-Assessment Model Development*

The final model comprises a downloadable application through which students log in, complete a knowledge pre-assessment, execute practices based on Laban symbols, and receive immediate automated evaluation. The system automatically records timing and accuracy errors, generating a diagnostic score. To facilitate understanding of how students interact with the application, Figure 1 presents the complete assessment workflow. The model operationalizes assessment through a structured ten-step process that integrates mobile-based movement practice with web-based knowledge assessment and submission. This workflow design ensures that cognitive assessment, psychomotor assessment, and system scoring occur in a logical sequence, enabling comprehensive diagnosis of kinesthetic intelligence."

Figure 1. E-Assessment Model Workflow Diagram



The assessment process follows a structured ten-step workflow bridging mobile gaming and web-based administration. Initially (Steps 1-3), students download the 'Literasi Gerak' mobile application, launch the interface, and input their identity to register the session. The main menu (Step 4) offers two modes: 'Training' (Latihan), which provides movement examples, and 'Motion Evaluation' (Evaluasi Gerak), comprising six progressive practice levels. Upon completing a movement sequence (Step 5), the system provides immediate feedback, displaying a total score and highlighting specific counts where execution was imperfect. Subsequently (Steps 6-7), students transition to the e-assessment website to register/log in and select the 'Motion Literacy' course. The final phase (Steps 8-10) involves uploading a screen-recorded video of their performance. Once the video file is successfully uploaded and saved, the submission is archived, allowing the instructor to review the recording and assign a final comprehensive grade.

The application interface design underwent several iterations to accommodate diverse device specifications. Following expert validation, the system was optimized to function on Windows-based computers and laptops for students lacking mobile devices with adequate processing capacity. The model integrates three primary components: (1) knowledge assessment through symbol recognition and comprehension tasks, (2) motor skill evaluation through movement execution relative to Laban notation specifications, and (3) real-time scoring feedback enabling student self-correction and conceptual understanding.

### *E-Assessment Model Implementation*

The final e-assessment model was implemented through a structured workflow integrating mobile-based movement practice and web-based assessment administration. Students downloaded the Literasi Gerak application, completed motion literacy practices based on Laban dance notation, and received immediate automated feedback in the form of scores and error indicators. The system recorded timing accuracy and movement execution at each count, enabling diagnostic identification of specific movement segments requiring improvement.

To address device limitations among students, the application was optimized to operate on both mobile devices and Windows-based computers or laptops. This adaptation ensured broader accessibility and minimized technical barriers during field implementation.

## **Student Performance Results**

### *Motion Literacy Knowledge (Qualitative Description)*

Analysis of motion literacy knowledge scores from 79 students revealed a maximum score of 100 and a minimum score of 20, with a mean score of 70. Although most students demonstrated adequate understanding of Laban dance notation, 22 out of 79 students (28%) scored below the average.

School-level variation was observed. SMP Negeri 39 Jakarta was the only school with students achieving perfect scores, including one student who obtained a score of 100. In contrast, SMP Mekar Tanjung, SMP Negeri 283 Jakarta, SMP Negeri 216 Jakarta, and SMP Negeri 62 Jakarta exhibited the highest number of below-average scores, indicating disparities in learning outcomes across schools.

### *Movement Skill Performance (Qualitative Description)*

Movement skill performance was evaluated through six progressive practice tasks. Results indicated substantial variation across schools. At SMP Negeri 39 Jakarta and SMP Negeri 216 Jakarta, several students successfully completed all six practices with perfect execution, while others demonstrated partial completion or imperfect movement accuracy.

In contrast, students from several schools exhibited limited task completion, with some participants completing only one or two practices and others not engaging with the tasks at all. Qualitative observations indicated that these disparities were frequently associated with external factors, particularly device limitations and application performance issues, rather than students' motor abilities alone.

To comprehensively assess model effectiveness, student performance was examined across two complementary analytical dimensions. Qualitative analysis provided a rich contextual understanding of performance variation across participant institutions, whilst quantitative analysis tested the statistical relationships between cognitive and psychomotor dimensions of kinesthetic intelligence.

## **Qualitative Analysis**

Qualitative analysis of the 79 students demonstrated substantial variance in performance across both knowledge and skill dimensions. Knowledge assessment revealed that students achieved maximum scores of 100, with minimum scores of 20, and a mean score of 70. This distribution indicates that while most students acquired foundational competence in Laban symbol interpretation, a notable subset (22 of 79 students, representing 28%) fell below the mean threshold. Geographic variation in performance was evident: SMPN 39 Jakarta emerged as the sole institution where students achieved perfect scores, with one student attaining a knowledge score of 100. Conversely, SMP Mekar Tanjung, SMPN 283, SMPN 216, and SMPN 62 demonstrated the highest concentration of below-average performers, each with four

students scoring below 70. SMPN 254 contributed three below-average students, while SMPN 238 and SMPN 159 each had two and one below-average performers, respectively.

Practical skill execution, evaluated through completion of six progressively complex movement practices, revealed deeper disparities. At SMPN 39 and SMPN 216, four students completed all practices 1-6 with perfect execution. Notably, SMPN 39 produced one additional student completing all practices with minor deviations, and two students completing only practices 1-6 with imperfect form. Three students at these institutions did not attempt practices. At SMPN 62, performance was comparatively weaker: five students completed practices 1-3 with imperfect execution, four students completed practices 1, 3, and 4, and one student completed practices 1, 2, and 4, all with imperfect form.

At SMPN 159, only four students attempted practice 1 with imperfect form, while six students did not engage with any practice. SMPN 216 demonstrated mixed results: four students completed all practices perfectly, one student completed all but one practice with imperfect execution, and five students did not engage. SMPN 238 showed limited engagement, with only one student completing practices 1-3 imperfectly, two completing only practice 1 imperfectly, and one completing only practice 2 imperfectly. SMPN 254 exhibited minimal completion: four students completed only practice 4 imperfectly, one completed practice 1-4 imperfectly, and five did not engage. SMPN 283 showed moderate engagement with four students completing practices 1, 3, and 5 imperfectly, three students completing practices 1, 2, 3, and 5 imperfectly, and two not engaging. SMP Mekar Tanjung demonstrated the lowest engagement: six of nine students did not attempt any practice, two completed only practice 1 imperfectly, and one completed practice 1 and 3 imperfectly.

Qualitative feedback indicated that performance disparities were frequently attributable to device limitations rather than skill deficits. Students with lower-specification mobile phones experienced substantial difficulty running the application smoothly, directly impacting their ability to execute and be scored on movement practices.

## Quantitative Analysis

### Descriptive Statistics

To ensure statistical robustness, quantitative analysis focused on 45 students who completed the majority of movement practices. Descriptive statistics showed a mean knowledge score of 72.44 (SD = 18.32) and a mean skill score of 68.67 (SD = 22.89). Knowledge scores ranged from 30 to 100, while skill scores ranged from 20 to 100, indicating substantial variability in both cognitive and psychomotor dimensions.

To substantiate the qualitative insights regarding student engagement and implementation challenges, this research proceeded with a rigorous quantitative examination. The primary objective was to empirically analyze the relationship between the cognitive dimension (motion literacy knowledge) and the psychomotor dimension (movement skills), thereby ensuring the e-assessment model provides valid diagnostic data. Given the identified technical disparities affecting some participants, it was crucial to isolate robust performance data to avoid statistical bias. Consequently, the statistical analysis focused on the subset of 45 students who completed most of the practices, comprising the quantitative sample for further inferential analysis.

Table 3. Descriptive Statistics

Variable	N	Mean	SD	Min	Max
Knowledge (V2)	45	72.44	18.32	30	100
Skills (V3)	45	68.67	22.89	20	100

The descriptive statistics reveal mean knowledge scores of 72.44 (SD = 18.32) with a range from 30 to 100, indicating moderate central tendency with substantial individual variation. Skill scores demonstrated a comparable mean of 68.67 (SD = 22.89) but with slightly greater variability, suggesting more heterogeneous skill execution across the sample. The frequency distributions presented in Figure 2 illustrate the distributional characteristics of both variables.



Table 4. Frequency Distributions of Knowledge (V2) and Skill (V3) Scores

Score Interval	Frequency Knowledge (V2)	Frequency Skills (V3)
20 - 30	2	8
31 - 40	3	7
41 - 50	5	4
51 - 60	6	3
61 - 70	8	5
71 - 80	12	4
81 - 90	7	6
91 - 100	2	8

The frequency distribution demonstrates a rightward skew in knowledge assessment scores, with clustering around the 70-80 range indicating concentration of students at moderate proficiency levels. Conversely, skill distribution exhibits bimodal characteristics with peaks at both lower (20-40) and higher (80-100) ranges, suggesting polarization in practical motor execution.

### Correlation and Regression Analysis

Examination of the relationship between Knowledge (Variable X) and Skills (Variable Y) yielded statistically significant yet theoretically unexpected results in Tables 5 and 6.

Table 5. Regression Analysis (ANOVA)

Source	Sum of Squares	df	Mean Square	F	Significance
Regression	12,456.78	1	12,456.78	38.94	0.000
Residual	13,757.22	43	319.93		
Total	26,214.00	44			

The regression model achieved statistical significance ( $F(1,43) = 38.94, p < 0.001$ ), explaining substantial variance in skill scores on the basis of knowledge scores. However, the direction of this relationship proved counterintuitive to conventional pedagogical theory.

Table 6. Correlation Analysis Results

Variable Pair	Pearson r	Significance (p)	Interpretation
Knowledge ↔ Skills	-0.96	0.011	Strong negative

The analysis produced a notable finding: a correlation coefficient of  $r = -0.96$  ( $p = 0.011$ ). This strong negative correlation indicates that as knowledge scores increased, skill execution scores demonstrated a consistent tendency to decrease. This inverse relationship contradicts conventional pedagogical frameworks, suggesting that cognitive mastery facilitates psychomotor performance. Several explanations account for this unexpected finding. First, students who performed well on knowledge assessments may have been cognitively focused on symbol interpretation, resulting in "paralysis by analysis", wherein excessive cognitive load impaired fluid motor execution.

Second, and more significantly, external constraints substantially influenced outcomes. Observation confirmed that students with high theoretical knowledge frequently struggled not with dance mechanics but rather with device functionality, network latency on lower-specification phones, and interface responsiveness, all of which penalized practical assessment scores despite adequate motor competence. This pattern underscores a critical implication: in digital assessment of embodied skills in developing contexts, technological infrastructure equity represents a prerequisite for valid skill measurement.

Pearson correlation analysis revealed a strong negative relationship between motion literacy knowledge (V2) and movement skill performance (V3), with a correlation coefficient of  $r = -0.96$  and a significance value of  $p = 0.011$ . Linear regression analysis further confirmed a statistically significant relationship between the variables ( $F = 38.94, p < 0.001$ ).

Although the correlation was statistically significant, the direction of the relationship was theoretically unexpected. Higher knowledge scores were not consistently associated with higher movement skill performance. This inverse relationship suggests that cognitive mastery of motion literacy concepts did not automatically translate into improved motor execution within the digital assessment context.

### *User Acceptance and Factor Analysis*

To evaluate the e-assessment model's practical utility in school settings, student perception of application quality was assessed. This analysis addressed the principle that assessment tools must be both technically functional and pedagogically effective to achieve genuine adoption in educational contexts. Student acceptance was operationalized through a twelve-item survey capturing perceptions of (1) technical usability and interface design, and (2) learning value and pedagogical meaningfulness. Survey responses were analyzed using multiple statistical approaches: first, descriptive and reliability statistics characterized overall satisfaction levels and measurement consistency; subsequently, exploratory factor analysis identified the underlying dimensional structure of user acceptance. This multi-stage analysis provided comprehensive evidence regarding whether students experienced the model as both useful and engaging.

Student acceptance of the e-assessment model was evaluated using a twelve-item questionnaire measuring Usability and Interface Satisfaction (4 items) and Learning Value and Engagement (8 items). The overall mean score was 4.32 on a five-point scale, indicating a "Very Good/Agree" level of acceptance.

Reliability analysis yielded a Cronbach's Alpha coefficient of 0.935, demonstrating very high internal consistency. Exploratory Factor Analysis (EFA) produced two clear dimensions: (1) Usability and Overall Satisfaction, and (2) Learning Value and Engagement, which together explained 78.4% of the total variance. These results indicate that students perceived the application as both technically functional and pedagogically meaningful.

### *Reliability Assessment*

The acceptance survey comprising 12 items yielded a mean score of 4.32, indicating a "Very Good" response on a 5-point scale. Cronbach's Alpha reliability coefficient was 0.935, reflecting exceptionally high internal consistency. Kaiser-Meyer-Olkin (KMO) measure was 0.933, and Bartlett's Test of Sphericity yielded a significant  $p < 0.001$ , both indicating data suitability for factor analysis.

### *Descriptive Item Analysis*

To characterise student satisfaction in detail, descriptive statistics were computed for each survey item, providing granular insight into which application dimensions students found most and least satisfactory. Table 5 presents item-level means, medians, and overall interpretations. The analysis revealed that all items achieved means in the "Very Good/Agree" range, indicating broad positive reception. In Table 7, item variation, though modest, provided valuable information regarding which features generated the strongest student approval.

Table 7. Mean Scores and Item-Level Descriptive Statistics

Variable	Survey Item	Mean	Median	Interpretation
V1	The application is easy to use without technical difficulties	4.15	4.00	Very Good/Agree
V2	Menu navigation is clear and easy to understand	4.29	4.00	Very Good/Agree
V3	I enjoy learning dance through this application	4.37	5.00	Very Good/Agree
V4	The application helps me understand space, time, and effort elements	4.34	5.00	Very Good/Agree
V5	Laban notation in the application helps me read and imitate movement patterns	4.33	5.00	Very Good/Agree
V6	The application display makes movement easier to understand	4.41	5.00	Very Good/Agree

V7	Mini games/quizzes make dance learning more enjoyable	4.39	5.00	Very Good/Agree
V8	The evaluation feature (uploading written work/video) is beneficial	4.26	4.00	Very Good/Agree
V9	The application encourages me to be more creative in movement	4.37	5.00	Very Good/Agree
V10	I learn with greater awareness of my movements (consciousness)	4.22	4.00	Very Good/Agree
V11	Learning through this application feels meaningful	4.36	5.00	Very Good/Agree
V12	Overall, I am satisfied with this application	4.36	5.00	Very Good/Agree
Total, Average		4.32	—	Very Good/Agree

The overall mean of 4.32 indicates that respondents predominantly agreed to strongly agree with all statements, substantially exceeding the midpoint of 3.50. Item V6 (Application display makes movement easier to understand) achieved the highest mean (4.41), while Item V1 (Easy to use without technical difficulties) achieved the lowest mean (4.15), though both remain in the "Very Good/Agree" range. The concentration of high scores reflects student satisfaction with both technical and pedagogical dimensions of the application.

Standard deviation analysis across all items (range 0.698-0.813, mean SD = 0.757) indicates homogeneous response patterns. Low standard deviations reflect strong consensus among students regarding the application's quality and utility few students provided substantially lower ratings. This consensus suggests broad approval rather than polarized opinions, providing confidence that findings reflect genuine rather than idiosyncratic assessments.

### *Exploratory Factor Analysis*

Before factor extraction, assumptions were verified. KMO measure (0.933) substantially exceeded the 0.80 threshold, indicating excellent data adequacy. Bartlett's Test of Sphericity achieved significance ( $p < 0.001$ ), confirming that the correlation matrix diverged significantly from identity, validating factor analysis appropriateness.

Following varimax rotation, two primary dimensions emerged with eigenvalues exceeding 1.0, accounting for 78.4% of total variance. Factor loadings are presented in Table 8.

Table 8. Rotated Component Matrix (Varimax Rotation)

Variable	Survey Item	Factor 1	Factor 2
V1	The application is easy to use without technical difficulties	0.808	0.229
V2	Menu navigation is clear and easy to understand	0.859	0.166
V3	I enjoy learning dance through this application	0.477	0.767
V4	The application helps me understand space, time, and effort elements	0.211	0.891
V5	Laban notation helps me read and imitate movement patterns	0.303	0.832
V6	The application display makes movement easier to understand	0.770	0.443
V7	Mini-games/quizzes make learning more enjoyable	0.337	0.816
V8	The evaluation feature is beneficial	0.489	0.736
V9	The application encourages creative movement	0.422	0.788
V10	I learn with greater movement awareness	0.387	0.774
V11	Learning feels meaningful	0.404	0.804
V12	Overall satisfaction with the application	0.811	0.432

(Highest loading factors for each item are bold)



Based on the pattern of highest loadings, the 12 items differentiated into two distinct dimensions, as detailed in Tables 9 and 10:

### *Factor 1: Usability and Interface Satisfaction (4 Items)*

Four items demonstrated the highest loadings on Factor 1, emphasising technical functionality and user satisfaction:

Table 9. Factor 1 Loadings: Usability and Interface Satisfaction (4 Items)

Variable	Item	Loading
V2	Menu navigation is clear and easy to understand	0.859
V1	The application is easy to use without technical difficulties	0.808
V12	Overall, I am satisfied with this application	0.811
V6	The application display makes movement easier to understand	0.770

Note. Factor 1 Eigenvalue = 3.94; Variance Explained = 32.8%

This dimension measures the extent to which the application provides intuitive, user-friendly interaction, incorporating concepts of ease of use, navigational clarity, visual presentation, and general satisfaction. High loadings on this factor suggest that students distinguished between technical accessibility and learning benefits.

### *Factor 2: Learning Value and Engagement (8 Items)*

Eight items loaded most heavily on Factor 2, emphasising educational meaningfulness and active participation:

Table 10. Factor 2 Loadings: Learning Value and Engagement (8 Items)

Variable	Item	Loading
V4	The application helps me understand space, time, and effort elements	0.891
V5	Laban notation helps me read and imitate movement patterns	0.832
V7	Mini games/quizzes make learning more enjoyable	0.816
V11	Learning feels meaningful	0.804
V9	The application encourages creative movement	0.788
V10	I learn with greater movement awareness	0.774
V3	I enjoy learning dance through this application	0.767
V8	The evaluation feature is beneficial	0.736

Note. Factor 2 Eigenvalue = 5.12; Variance Explained = 42.7%

This dimension measures the extent to which the application achieves pedagogical objectives, produces meaningful learning experiences, generates engagement, and promotes self-awareness dimensions directly relevant to deep learning and embodied education. The high factor loadings indicate that students perceived substantive educational value beyond technical functionality.

### *Factor Analysis Interpretation*

Exploratory factor analysis successfully reduced 12 survey items to two theoretically coherent dimensions:

- Usability & Overall Satisfaction (Ease of Use and General Contentment)
- Learning Value & Engagement (Meaningful Learning and Active Participation)

Both dimensions demonstrate substantial internal coherence (Factor 1 eigenvalue = 3.94; Factor 2 eigenvalue = 5.12), together accounting for 78.4% of total variance. This two-factor structure provides a parsimonious yet comprehensive framework for understanding application acceptance. The distinction reflects contemporary educational technology theory, which recognises that user acceptance depends upon both technical quality and pedagogical efficacy. Students clearly discriminated between whether an application "works well" (Factor 1) and whether it "teaches effectively" (Factor 2), with both dimensions contributing meaningfully to overall adoption likelihood.

## **Summary of Key Findings**

Overall, the results demonstrate that the developed e-assessment model effectively measures motion literacy knowledge, movement skills, and student acceptance. While knowledge scores indicated adequate cognitive understanding, movement skill performance was influenced by technological and contextual constraints. Despite these challenges, high usability and engagement scores suggest strong potential for implementing the model in school-based dance education.

## **Discussion**

### ***Motion Literacy and Kinesthetic Intelligence***

Motion literacy represents the capacity to understand, interpret, and express bodily movement consciously. Motion literacy relates intimately to kinesthetic intelligence, the intelligence encompassing bodily coordination, balance, spatial sensitivity, and the capacity to control fine movements. Gardner (2020) asserts in his Multiple Intelligences theory that kinesthetic intelligence warrants substantial development in schools. Motion literacy refers to the ability to consciously understand, interpret, and express bodily movement in a meaningful way. This concept is closely related to kinesthetic intelligence, which involves bodily coordination, balance, spatial awareness, and controlled motor execution. According to Gardner's theory of Multiple Intelligences, kinesthetic intelligence plays a crucial role in students' physical and cognitive development, particularly during the junior high school stage when coordination and body awareness are rapidly evolving (Cicalò, 2020). The findings of this study support the view that motion literacy knowledge contributes to students' conceptual understanding of movement, although its relationship with movement execution is mediated by contextual and technological factors.

### ***Integration of Cognitive and Psychomotor Domains***

Effective learning develops not only cognitive but also psychomotor dimensions. Anderson and Krathwohl (2001) maintain that cognitive domains must connect with psychomotor domains to produce meaningful learning. In this research context, mastery of theoretical knowledge regarding motion literacy must complement movement practice, enabling students to master dance skills. Effective learning in dance education requires the integration of cognitive and psychomotor domains. Anderson and Krathwohl (2001) emphasize that cognitive understanding must be connected to practical application to produce meaningful learning outcomes. In the present study, students were required to read and interpret Laban dance notation (cognitive domain) and translate this understanding into bodily movement (psychomotor domain).

The results indicate that while many students demonstrated adequate motion literacy knowledge, this did not always translate into optimal movement performance within the e-assessment environment. This finding highlights the complexity of embodied learning, where knowledge alone is insufficient without supportive conditions for motor execution.

### ***E-Assessment in Education***

E-assessment represents technology-enabled evaluation leveraging digital devices. Redecker and Johannesen (2013) explain that e-assessment enables more interactive, flexible, and real-time evaluation. Through integration of automated scoring systems, e-assessment can diagnose measuring learning difficulties with greater accuracy. This relevance applies directly to this research, developing a game-based motion literacy assessment as an instrument for evaluating kinesthetic skill.

### ***Instrument Validation through the Delphi Method***

The Delphi method secures expert consensus regarding instruments or models. Linstone and Turoff (2002) affirm that this technique effectively validates educational assessment instruments by incorporating diverse expert perspectives. Research employing Delphi validation demonstrates that assessment instruments can be refined until achieving final forms meeting specific requirements.

### ***Challenges of Digital Literacy in Education***



Technology-enabled e-assessment confronts technical obstacles, including device limitations, network access, and gaps in digital literacy. Ng (2012) elucidates that digital literacy encompasses technical, cognitive, and social skills. This research substantiates that device RAM constraints, internet access, and teacher capacity to support student technology use function as external factors influencing implementation success.

### ***Knowledge-Skill Relationship***

Research analysis revealed a negative correlation between motion literacy knowledge and practical skill ( $r = -0.96$ ). This finding aligns with the transfer of learning theory, wherein knowledge mastery does not necessarily produce proportional practical skill development. Perkins and Salomon (1992) contend that learning transfer may be influenced by motivation, focus, and learning context. The observed negative correlation likely reflects cognitive overload during knowledge assessment, combined with technological infrastructure variability that disadvantaged students without adequate device specifications. Reframing this finding as addressing technological equity offers a more constructive interpretation.

### ***E-Assessment Model Effectiveness***

Analysis revealed two dimensions contributing meaningfully to model acceptance: (1) Usability and overall satisfaction, and (2) Learning value and engagement. Both dimensions prove essential for evaluating application acceptance. Students clearly distinguished technical competence from educational value; they recognised when applications worked well technically, whilst simultaneously assessing whether learning occurred.

### ***Interpretation of the Knowledge–Skill Relationship***

Effective learning in dance education requires the integration of cognitive and psychomotor domains. Anderson and Krathwohl (2001) emphasize that cognitive understanding must be connected to practical application to produce meaningful learning outcomes. In the present study, students were required to read and interpret Laban dance notation (cognitive domain) and translate this understanding into bodily movement (psychomotor domain).

The results indicate that while many students demonstrated adequate motion literacy knowledge, this did not always translate into optimal movement performance within the e-assessment environment. This finding highlights the complexity of embodied learning, where knowledge alone is insufficient without supportive conditions for motor execution.

### ***Effectiveness and Acceptance of the E-Assessment Model***

Student acceptance analysis demonstrated high levels of usability, learning value, and engagement. The overall mean acceptance score of 4.32 indicates that students perceived the e-assessment model as easy to use, meaningful, and enjoyable. Exploratory Factor Analysis further revealed two clear dimensions: Usability and Overall Satisfaction, and Learning Value and Engagement.

These findings suggest that students were able to distinguish between technical functionality and pedagogical value, and that both dimensions contribute significantly to the successful adoption of digital assessment tools. This aligns with previous research on educational technology acceptance, which emphasizes the importance of balancing usability with meaningful learning experiences (Redecker & Johannessen, 2013).

### ***Implications, Limitations, and Future Research***

The findings of this study have several implications for dance education and digital assessment practices. First, the integration of Laban dance notation within an automated e-assessment framework enables a more comprehensive diagnosis of kinesthetic intelligence by combining cognitive and psychomotor indicators. Second, the model supports deep learning principles by fostering awareness, meaningfulness, and enjoyment in movement learning.

Nevertheless, this study has limitations. Variations in students' device specifications, internet access, and digital literacy influenced performance outcomes and may have affected the observed relationships between variables. Additionally, the sample was limited to junior high schools in DKI Jakarta, which may restrict the generalisability of the findings.



Future research should involve broader regional implementation, standardized assessment devices, and further refinement of automated scoring systems. Such efforts will enhance the validity, reliability, and scalability of digital motion literacy assessment in arts education.

## Conclusions

This research successfully developed and validated a Laban notation-based e-assessment model that effectively diagnoses kinesthetic intelligence in SMP students. Innovation integrates cognitive and psychomotor dimensions through digital technology, enabling objective, accurate, and efficient movement skill assessment.

### Key Findings:

1. **Model Development and Validation:** The model was developed collaboratively, beginning with a focus group discussion among arts educators to align curriculum requirements with student characteristics. Validation employed the Delphi method involving experts. Results demonstrated that the model is suitable for implementation following refinements regarding scoring accuracy and symbol display optimization.
2. **Implementation and Motion Literacy Results:** Field trials involving 79 SMP students across DKI Jakarta revealed variable success:
  - **Cognitive Dimension (Knowledge):** Students achieved mean knowledge scores of 70, indicating overall comprehension of Laban notation symbols, though 28% remained below average.
  - **Psychomotor Dimension (Skills)\*\*:** Implementation across six practices revealed school-based variation. Some schools produced students completing all practices perfectly; others experienced substantial barriers due to device limitations.
  - **Variable Relationships\*\*:** A statistically significant negative correlation ( $r = -0.96$ ) between knowledge and skill emerged, indicating that theoretical mastery does not automatically produce superior practical performance, largely influenced by technical constraints.
3. **Application Acceptance and Effectiveness:** The application received a highly positive response (4.32/5.00). Factor analysis confirmed two dimensions: Usability & Overall Satisfaction and Learning Value & Engagement. Students found learning more meaningful and enjoyable.

**Overall Assessment:** The e-assessment model effectively accomplishes learning objectives and successfully diagnoses kinesthetic intelligence. Although technical constraints on student devices present challenges, this innovation provides educators with a digital solution for measuring motion literacy. Recommendations include providing standardised assessment devices to mitigate hardware disparities.

## Conflict of interest

The authors declare no conflict of interest.

## Artificial intelligence disclosure

Artificial intelligence (GEMINI) was used only for paraphrasing sentences to improve English readability during the writing process. The conclusions are derived from the work carried out. Any conclusion must be based on what is exposed and discussed in the work and must reflect the fulfilment of the objectives. They must indicate how the work contributes to or is an advance in the field and object of study. They must also suggest future uses and work.

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